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instances, each jump was made in a different direction from the last, so that it was a matter of some difficulty to pursue the little creature! I was exceedingly interested in this first capture—never having seen or heard of one before. One of our farm hands told me that it was a “kangaroo mouse.” After that I saw one occasionally, and my recollection is very clear that Godman does not overstate its ability to jump. I have never seen or heard of one in this region.—*Charles Aldrich, Webster City, Iowa, March 5, 1885.*

### EMBRYOLOGY.<sup>1</sup>

ON THE PROBABLE ORIGIN, HOMOLOGIES AND DEVELOPMENT OF THE FLUKES OF CETACEANS AND SIRENIANS.—We have seen that the development of the Physoclist fishes (*AM. NATURALIST*, 1885, pp. 315–317), shows that the translocation of the pelvic fins forward is accomplished in some forms in about twenty-four to forty-eight hours, to a position more or less in advance of the pectoral. If a limb-fold can be translocated forwards in a vertebrate embryo from its archaic site, there is no reason to doubt that under certain conditions it might be translocated in the other direction or backwards. A process of translocation of the distal end of the pelvic limbs seems to have occurred in the cetaceans, as a consequence of which the pes has acquired a new position far to the rear of that which it occupies in normal mammals, and this seems to have been accompanied by processes of atrophy in some directions and hypertrophy in others.

The researches of Struthers, Flower, Reinhardt, Eschricht, Kaup, Lepsius, Howes and Wilder, leave no doubt as to the fact that the different rudimentary structures which these anatomists have detected, unequivocally point to the conclusion that, the cetaceans and sirenians have descended from Mammalia which possessed more or less perfectly developed ambulatory limbs, which fitted them at least for an amphibious or partially terrestrial existence. This conclusion is, I believe, generally accepted by recent authorities.

All recent writers, amongst which may be named Flower, Huxley, Owen, Claus and Parker, unequivocally declare that the hind-limbs of the whales and sirenians have been so completely suppressed, that no rudiments or vestiges of any kind have remained to indicate outwardly that these creatures ever possessed such appendages, the evidence that they did once possess hind-limbs resting for them rather upon the presence of a rudimentary pelvis with much reduced limb-bones in a few forms of *Balænoidea* and in *Halitherium*.

From this view the writer must dissent, having independently arrived at conclusions in reference to the homology of the flukes

<sup>1</sup> Edited by JOHN A. RYDER, Smithsonian Institution, Washington, D. C.

very similar to those published by Professor Gill<sup>1</sup> in 1882, who regards these characteristic structures as having been derived from greatly hypertrophied integuments of hind-limbs analogous to such as are developed, for instance, to the hind-limbs of the eared seals, while the osseous elements have been inversely atrophied, pulled forwards, and reduced to supports for muscles connected with the organs of generation. It may, I think, be regarded as a fact that there is no evidence to show that development does not attempt to recapitulate in a disguised form, in the cetacean foetus, the outgrowth of the hind-limb as seen in a normal mammalian embryo.

In the mammal the pectoral limb is the first to appear, the pelvic appearing last. If the flukes be regarded as the outward vestiges of hind-limbs or pedes, then will the embryos of cetaceans and sirenians conform to this law presiding over the order of appearance of the limbs, which, so far as I am aware, is regnant without exception within the limits of the vertebrate class. The dorsal fin with which the flukes have so often been mistakenly compared, is not present in all cetaceans; is absent in all sirenians; is not constant in position in different genera of the former; is sometimes a mere carina, dorsal ridge or hump; its vascular and nerve supply is different from that of the flukes; it develops after the latter, showing that it is a later acquirement; it has absolutely no connection with muscles directly or indirectly by tendons as have the flukes, so that I regard the comparison of the dorsal fin, which is a mere dermal fold, with the flukes, as expressing a mistaken apprehension of anatomical homologies, and not justified in the face of the fact that the flukes are never absent, and always appear laterally or serially in the position of a hind limb-fold, though backwardly displaced. It must, however, be stated that I distinctly disavow the affirmation that the flukes are homologous with more than the pedes of normal forms. The older views which intimated that the flukes were the representatives of limbs or of feet, it is not worth while to discuss, as these writers did not possess the data upon which to base any reasons for their opinions, which seem to have been in the main intuitional.

The hypothesis which is offered to account for the flukes as the distal vestiges of limbs rests upon the following arguments:—1. The mode of outgrowth of the flukes in the embryo, prior to the dorsal fin, at the end of the sides of the tail, at first as a pair of low rounded lobes or folds of skin, containing mesoblast, which become gradually falcate, and which expand posteriorly so as to leave a notch over the end of the tail between their inner edges. The hind margin of the flukes answering to the terminal border of the pes or the ends of the suppressed toes or the integuments extending beyond them, and their anterior margin to the outer

<sup>1</sup> Scientific and popular views of nature contrasted. A lecture delivered in the National Museum, March 11th, 1882. Pp. 10–11. Washington, Judd & Detweiler.

digital border. 2. The existence of a small median papilla, according to Wilder, at the extreme end and under side of the tail of the foetus of the manatee, representing apparently the last vestige of an exserted tail extending beyond and behind the fluke folds of this type, in which the flukes are in fact rudimentary. 3. The fact that the osseous elements of the limb have atrophied exactly in the reverse order in which they appear in the embryo, or from without inwards, that is, from behind forwards in cetaceans and sirenians, because in both, the hind-limbs have been rotated or extended permanently backwards distad of the knee-joint. 4. The structure of the embryonic fluke-folds or diverticula filled with mesoblast comparable to that found in the limb-folds of other vertebrate embryos, these limb-buds representing structures which have survived translocation and made an attempt to imperfectly recapitulate the development of part of the limb.

The above headings present the embryological argument. The other data are anatomical and are mainly based on a comparison of the pinniped and cetacean types. Admitted that the cetaceans are descended from land forms, we would naturally look to types of amphibious habits and poorly adapted for progression upon land to furnish the first indications of modifications which have been carried to an extreme degree in the former. Traces of the beginnings of such modifications we actually find in pinnipeds.

In the pinnipeds, the hind limbs, from the knees, have been rotated backward and included by a continuation of the integument which invests the body together with the tail, leaving only the last two or three short caudal vertebræ exserted or projecting into a caudal integumentary pocket, lying between the distal parts of the backwardly extended limbs. This process of inclusion, if carried to an extreme stage, would finally cause the whole of the tail to be lost to sight outwardly, leaving only the metapodial and phalangeal parts free. As a result of this arrangement in the pinnipeds certain muscular insertions of the limb muscles have been moved backwards, and the hyposkeletal flexors of the trunk have become more powerful; the abdominal muscles extending over the knees have restricted the movements of the femur. As a further result of this restricted movement the pelvis has begun to degenerate, the symphysis pubis become less defined, and the femur shortened. We are therefore, I submit, the actual witnesses of a process in the pinnipeds which if carried still further would bring about the condition now found in living cetaceans. The pedes in pinnipeds have been hypertrophied together with the metapodial and phalangeal elements, but are not the fingers also lengthened and their joints multiplied in the cetacean manus? In the Plesiosaurs, Ichthyosaurs and Lyrifera or true fishes, the same thing has occurred, namely hypertrophy and lengthening or increase of limb-elements comparable to phalanges, with a corresponding shortening of the proximal bones in contact with

the shoulder and hip-girdles. Manifestly the pes of a form like Megaptera, if mobile, would require a system of phalanges as powerful as those in the manus, but the pes is not mobile in any cetacean, on its own base, as is the fore-limb, but is rigidly affixed to the sides of the end of the tail and incapable of independent movement, hence the atrophy of its bones. The only evidence remaining to indicate that the pedes or flukes of cetaceans were once possessed of well-developed phalanges, is the distribution of the dorsal and ventral interdigital arteries, the arrangement of these in fact indicating that there was a great inequality in the length of the digits of the pes, the same as we now see in the manus, thus leading to the conclusion that the foot-structure of the ancestral or protocetacean type was so far different from that of the pinnipeds.

The next step in the process would be the atrophy of the limb-bones and muscles, which, on account of still greater restriction of their movements, would become useless, leaving the integuments of the feet as the flukes on either side of the end of the tail, which, with the total abandonment of the land by the animal, would become stronger and its centra greatly developed, carrying the pedal folds or flukes still farther rearward, and thus increase still more the interval between them and the remnants of the pelvis. At the same time, the muscles of the tail would become greatly developed, so that in the cetaceans we actually have the spectacle of an animal type which has descended from a land form with a degenerate tail again acquiring a tail of the functional importance of that of a fish, but structurally very dissimilar, especially as regards the arrangement of its muscles, which are not homologous with the muscular somites of a fish's tail. The pes thus becomes the only outwardly apparent part of the hind limb, just as the manus is the principal part exerted in the fore-limbs of cetaceans, where some of the muscular insertions have also been shoved outward or into a more distal and effective position. The inclusion of the end of the tail of cetaceans between the flukes has also differentiated the caudal vertebræ of the latter into two distinct and well-marked series, so that the centra, as respects their vertical diameters, do not taper from the sacral region backward, as in other mammals, but only from in front of the flukes backward.

The arrangement of the vessels of the manus and flukes is somewhat similar, but totally unlike that of the vessels entering the dorsal fin, which has only a median system, whereas the flukes have about ten dorsal and as many plantar vessels just under the integument, the prolonged fourth of these, reckoning from the anterior border of the fluke, being the analogue of the prolonged interdigital artery lying between the second and third digits of the manus, and which supplies the end of the flipper with blood, just as the outer two-thirds of the flukes are supplied by the prolonged fourth dorsal and ventral pair spoken of above.

Finally, it may be said that the rudimentary tibia, when present, is directed backward in the cetaceans just as in pinnipeds, showing that if it were fully developed and prolonged it would carry the pedes far behind a vertical line drawn through the hip-joint. There is also other evidence that the inclusion of the hind limbs in the whales has occurred in much the same way as in pinnipeds, for example, the femora are adducted to a remarkable degree in *Balaena*, according to Struthers, showing that the encroachment of other parts must have been the principal cause of such adduction. The femora of *Halitherium* seem also to have been directed backward toward the flukes, according to the figures given by Lepsius.

The translocation of the pedes of cetaceans has been accomplished through an extended phyletic series and was not sudden or partially saltatory as in the case of the pelvic limbs of embryo physoclists. The translocation in the first case was due to the backward extension of the limb, outwardly carrying only the pes away from its original place, in the latter the whole limb is shifted together with the girdle. In cetaceans there has been little or no shifting of the pelvic girdle, its detachment from the vertebral column being due to the atrophy of the ilium. The extension backwards of the limbs and pedes parallel with the caudal portion of the vertebral column, obviously began in an amphibious mammalian type and has thus *gradually* brought the pedes to their present position, where they appear ontogenetically; heredity, through immediate ancestry, here, as in many other cases, greatly marring the phylogenetic record. This gradual shifting, according to the method described, completely does away with the difficulty suggested by Flower as to the helplessness of the animals during the transfer, which really began in forms already to a great extent helpless on land but certainly not in the water.

The foregoing gives the principal anatomical and embryological grounds for regarding the flukes of Cetacea as the representatives of pedes translocated backward by rotation and extension of the limb rearward into a position parallel with the tail by the process of inclusion as described above, but as it is impossible to consider the evidence in favor of this conclusion in detail in this brief abstract, those interested are referred to my illustrated memoir on the subject almost ready for publication by the U. S. Fish Commission.—*John A. Ryder.*

#### PSYCHOLOGY.

INTELLIGENCE OF THE LIMPET.—By far the larger number of limpets “roost” upon rocks whose only covering consists of minute green algæ and millepores, together with numerous acorn barnacles. These last are seen to be of very unequal degrees of “cleanliness,” some being covered with vegetable growth, others quite white and bare. Those immediately surrounding a limpet or group